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WIOLETTA WRZASZCZ[1], JOLANTA SOBIERAJEWSKA

Institute of Agricultural and Food Economics – National Research Institute, Poland

RENURE – PROCESSED NATURAL FERTILIZERS. SELECTED ENVIRONMENTAL, PRODUCTION-ECONOMIC ISSUES

Key words: RENURE, natural fertilisers, European Green Deal, sustainable agricultural development, Nederlands

ABSTRACT. The aim of the paper is to present the essence of natural fertilizers in the form of RENURE, taking into account environmental and production-economic issues. For several decades, international programs and strategies for sustainable development have been implemented. The need to achieve various objectives in business activity is also underlined by the European Green Deal strategy, introduced at the end of 2019. An important element of it is the correct management of natural fertilizers, both for environmental and production and economic reasons. The case of the Netherlands was presented, where pilot studies on the conversion of manure into RENURE were introduced. The study used literature sources and selected, recent statistics from Eurostat resources (2019, 2020). Agriculture in the EU countries in the context of production and possibilities of using natural fertilizers is illustrated. The analysis of statistical data has shown that agriculture in the EU is highly diversified in terms of manure management. The case of the Netherlands, which has implemented the RENURE pilot program, results from the specificity of their agriculture – a small area of the country, a very high population and a high stocking density of livestock. Countries that face similar agricultural challenges as the Netherlands can seek similar solutions. In the case of Poland, which differs significantly in terms of the organisation of agriculture and its natural management conditions, the economic and environmental justification for the introduction of RENURE is not justified on a sector-wide scale.

[1] Corresponding author: wrzaszcz@ierigz.waw.pl

INTRODUCTION

Since the beginning of the 90s of the twentieth century, the need for sustainable agricultural development has been emphasized in the Common Agricultural Policy. Successive reforms highlight the increasingly strong focus on support for agricultural activities providing various benefits for society, including environmental and climate. Although the economic objective remains the main objective for the agricultural producer, the management should be carried out in accordance with respect for natural resources also used in agricultural activities [Zegar 2012, Matuszczak 2020]. Taking into account the long-term objectives of agricultural production, the implementation of production and economic goals is not possible in conditions of degradation of the natural environment and without the provision of ecosystem services [Wrzaszcz, Prandecki 2019].

The European Green Deal strategy, announced at the end of 2019, as well as subsequent strategies directly related to agriculture, such as the Farm to Fork Strategy, the 2020 Biodiversity Strategy or the new EU Circular Economy Action Plan, underline the importance of environmental practices in ensuring food security [EC 2019, 2020a, 2020b, 2020c]. These documents indicate the objectives and thus the challenges that European agriculture will face in the coming years (until 2030). Of the several specific objectives for agriculture, one relates to fertilizer management. The strategic objective for the European Union (EU) is to reduce nutrient losses by at least 50%, preventing soil fertility from deteriorating, which should lead to a reduction in fertiliser use of at least 20% [EC 2020, Matyka 2021]. This objective concerns the EU, while national objectives result from the specificities of their agriculture and the scale of problems related to fertilizer management. In the case of Poland, through many months of negotiations, the strategic goal was to reduce the result of the nitrogen balance from 48 kg per ha to 47 kg per ha per year, as well as phosphorus from 2.5 kg per ha to 2.4 kg per ha.

The main source of nutrient supply to the soil and plants are fertilizers, including mineral, natural, and additional – symbiotically bound nitrogen, as well as seed and precipitation [Wrzaszcz, Kopiński 2020]. Taking into account market conditions regarding agricultural inputs, an important argument for rationalization of fertilization are economic premises resulting from high prices of mineral fertilizers [MRiRW 2022, Wrzaszcz 2023, Zalewski 2023]. Natural fertilizers are a valuable source of nutrients [Kopiński, Krasowicz 2021], however, their use is associated with the need to store them and applicate in appropriate way, in safe conditions for the natural environment, climate and society. Due to the importance of production of natural fertilizers, as well as the economic conditions taking place on the mineral fertilizers market, technological solutions enabling the use of natural fertilizers are sought, taking into account organizational simplifications and environmental and climate standards. The use of new technologies, including in agriculture, requires investment and measurement of the actual results of the implemented solutions.

An alternative to the use of natural fertilizers in the processing is also the so-called RENURE (REcovered Nitrogen from manURE). The issue of the use of alternative sources of nitrogen recovered from processed manure (RENURE) is a new issue.

The aim of the paper is to present the essence of natural fertilizers in the form of RENURE, taking into account environmental and production-economic issues. The case of the Netherlands was presented, where pilot studies on the processing of manure were introduced.

MATERIAL AND METHODOLOGY OF RESEARCH

Eurostat data on European agriculture were used to show the diversity of agriculture in manure management between the EU countries. The latest, available data were used, which concerned the years 2019 and 2020. The results concerning the specificities of European agriculture, including the agricultural area and livestock population and stocking density, as well as the nitrogen balance, are illustrated, which inform about the potential burden of natural fertilizers on the natural environment [Wrzaszcz, Kopiński 2019].

In the case of RENURE, reference was made to source material made available by the Embassy of the Kingdom of the Netherlands and the Ministry of Agriculture and Rural Development (MRiRW). On the basis of the literature on the subject, the essence of RENURE and the importance of this form of natural fertilizers in the environmental and production context were discussed, also indicating the production and economic results established so far.

RESEARCH RESULTS AND DISCUSSION

THE SPECIFICITY OF AGRICULTURE IN THE EU – THE STARTING POINT FOR THE ASSESSMENT OF RENURE FERTILIZERS

The development of production technologies for the processing of natural fertilizers is dictated by the specificity of agricultural production in a given country and its financial and investment capabilities. The basic determinants in this respect, in addition to processing costs, are the agricultural area, livestock population and stocking density and the balance of the main fertilizing components.

The total agricultural area (UAA) in the EU in 2020 was 157.4 million ha (Figure 1). France, Spain, Germany and Poland are the countries with the largest areas of production in the EU agricultural sector. Total, these 4 countries account for more than half of the maintenance area. At the opposite end are the countries with a small agricultural area,

which includes the Netherlands, which has 1.2% of the EU's maintenance area, i.e. around 1.86 million ha.

In addition to the agricultural area, the production potential is determined by the livestock population. Based on Eurostat's livestock conversion rates, the total EU population in 2020 was 113 million livestock units (LSU). The distinguishing countries in this respect are France, Spain, Germany and Poland, which accounted for more than half of the EU's livestock. In the case of the Netherlands, the livestock population was 5.5 million, while in Poland it was 8.8 million LSU (Figure 2).

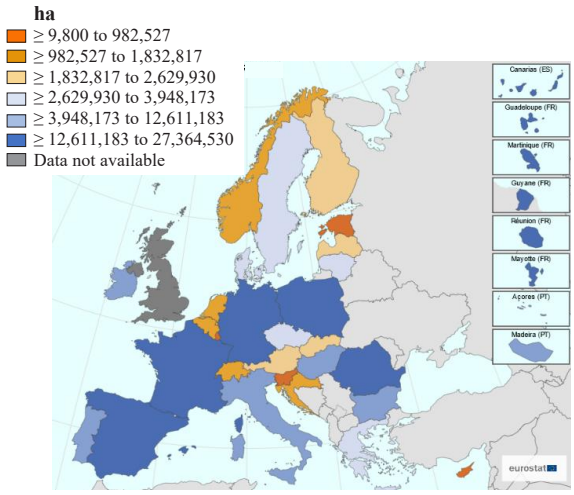

Figure 1. Agricultural area in the EU in 2020

Source: own elaboration based on Eurostat data

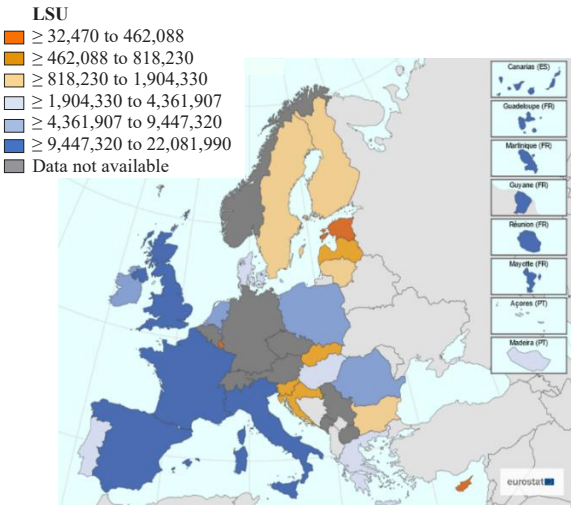

Figure 2. Livestock population in the EU in 2020

Source: own elaboration based on Eurostat data

An important indicator of livestock density was used to assess the potential intensity of natural fertilization (Figure 3). Against the background of the EU average of 0.7 LSU per ha in 2020, the Netherlands stood out particularly with a result of 3.4 LSU per ha, followed by Malta, Belgium, Cyprus, Denmark, Ireland and Luxembourg – i.e. countries with a much smaller area of maintenance in the EU. The stocking density in Poland was at a similar level to the average, placing it in the middle position among European countries. These results illustrate the scale of the challenges faced by agriculture – mainly in the Netherlands – in terms of proper management of the manure produced.

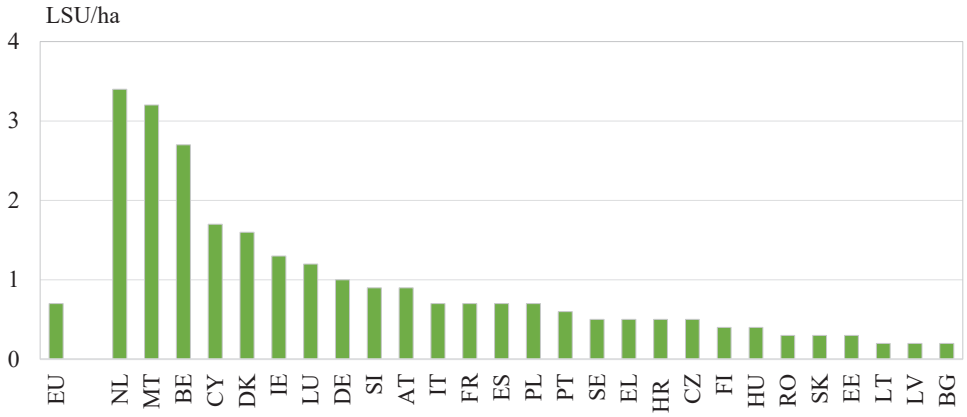

Figure 3. Stocking density in the EU countries in 2020 (country symbols included in Eurostat)
Source: own elaboration based on Eurostat data

The amount of surplus fertilizing component depends to a large extent on the amount of fertilizer applied (Figure 4). Among the EU countries that provided data for 2019, the Netherlands (369 kg per ha) was at the forefront in terms of fertilization intensity, followed by Germany (179 kg per ha) and the Czech Republic (163 kg per ha). The result for Poland was definitely lower and amounted to 125 kg per ha. These results outline the scale of the problem in some EU countries.

A synthetic determinant of environmental pressure is the result of the nitrogen balance (Figure 5). In 2019, the Netherlands occupied a leading position in terms of generated nitrogen surpluses (166 kg N per ha). For comparison, the result for Poland was at the level of 47 kg per ha.

According to Eurostat data, manure management is responsible for 1.5% of total greenhouse gas emissions, with both methane CH_4 (including intestinal fermentation) and

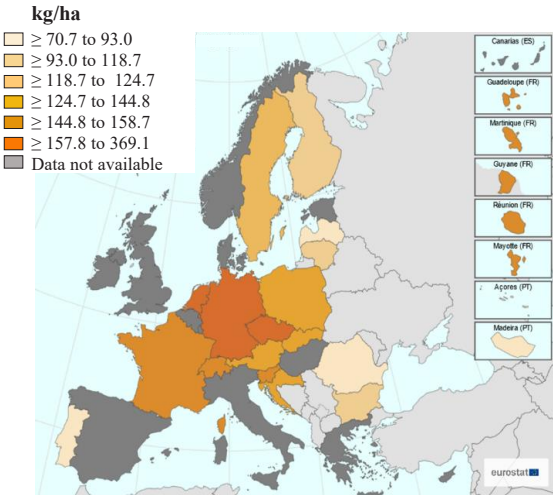

Figure 4. Amount of nitrogen contributed to the soil in 2019

Source: own elaboration based on Eurostat data

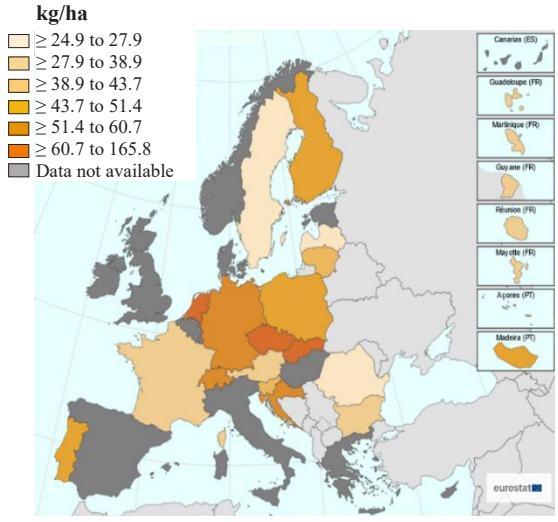

Figure 5. Result of nitrogen balance in 2019

Source: own elaboration based on Eurostat data

nitrous oxide N_2O (including soils) accounting for the main share[2]. Among the Member States, the Netherlands, Belgium, Malta and Luxembourg recorded the highest emissions per hectare of UAA used in 2015 – at least twice the EU-28 average (including the UK) (Figure 6). This result reflected a higher level of intensification of agricultural activity, including livestock in these countries.

[2] Another important gas is ammonia. According to estimates, the EU agriculture is responsible for over 92% of emissions of this gas, while in Poland for 94%. There are 2 dominant sources of NH_3 emissions, namely: livestock manure management responsible for about 79% of emissions in this sector and the use of nitrogen mineral fertilizers – about 21% of emissions [MRiRW 2023].

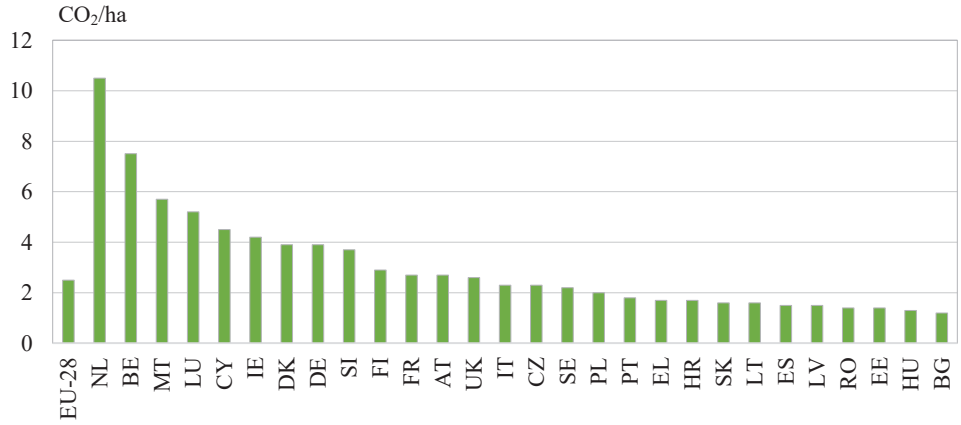

Figure 6. Gas emissions per hectare in 2015
Source: [Huygens et al. 2020]

RENURE (REcovered nitrogen from maNURE) – ESSENCE AND MEANING[3]

The European Green Deal strategy encourages intensification of activities aimed at searching for production methods and techniques aimed at reducing nutrient losses from natural fertilizers. The obtained natural raw material is generally intended for fertilizing agricultural land, which results from the importance of production of natural fertilizers, as well as environmental – building soil organic matter. Surplus manure produced in some agricultural holdings may be sold to cover the fertilizing needs of other farms, mainly livestock farms, and also used as raw material in the processing process. Processing of manure is mainly used to improve the manageability and use of livestock manure. Other purposes of manure processing may include the reduction of emissions to the atmosphere (ammonia, odors, greenhouse gases, etc.) as well as energy production [Ledda et al. 2013, Giner Santonja et al. 2017].

In some regions of the EU with a high stocking density, manure is produced in quantities where it cannot be fully applied to the place of production. An alternative to the use of natural fertilizers in the processing process is, e.g. the so-called RENURE. It is a new type of fertilizer in which there is any substance containing nitrogen wholly or partly derived from manure (recovery by processing manure) and which can be used in areas with nitrogen water pollution, and which also provides appropriate agronomic benefits to increase plant growth. Currently, there is a maximum use limit of 170 kg N per ha

[3] Technical issues related to RENURE are presented, e.g. in the paper H.J. Smita [2022].

per year in these areas based on the so-called Nitrates Directive. The introduction of the RENURE fertilizer category can promote agricultural practices that do not hamper the objectives of the Nitrates Directive, while at the same time improving nutrient efficiency from manure in agriculture and contributing to reducing greenhouse gas emissions from the production of nitrogen-containing mineral fertilizers [Huygens et al. 2020].

The production of RENURE – requiring the use of modern technologies – aims to reduce the amount of nitrogen that enters the atmosphere as a result of the production of organic, liquid nitrogen fertilizers. Member States facing the problem of "overproduction" of manure and willing to invest in this technology of natural fertilizer production may show interest in this technological process. Currently, the production of RENURE is mainly recognised in the Netherlands.

EXPERIENCES OF THE NETHERLANDS

In the Netherlands, since 2014, an annual inventory of export and processing capacity of manure has been carried out. The essence of activities aimed at promoting such an approach is the replacement of high-quality mineral fertilizers with processed natural fertilizers. According to the estimates of the Dutch, the production of processed natural fertilizers reduces spending on mineral fertilizers by 30-70% (data for 2022). The current production and use of fertilizers that would meet the RENURE criteria in the Netherlands is about 400 thousand tonnes per year, which corresponds to about 2.5 million kg of nitrogen (average nitrogen concentration is 6-8 kg N per tonne of product). Currently, low-emission techniques are used in the Netherlands using RENURE for fertilization. The resulting RENURE product consists mainly of mineral nitrogen (N_{min}) [Smit 2022].

Under the government's nitrate action programme, the Netherlands is implementing two pilot schemes, involving 10 companies and a total of 19 installations, mainly located in manure processing plants and large pig farms. In total, around 160 operators process manure, but they have standard rules for the maximum nitrogen consumption rate (up to 170 kg N per ha). The most commonly used technique is reverse osmosis (approx. 25% of companies), often in combination with an ion exchanger. On the other hand, 13% of entities use ammonia drainage/rinsing in thin fraction processing. In the reverse osmosis process (Figure 7), three products are formed: solid fraction (organic matter and phosphates), constituting approx. 20%, liquid fertilizer NK (RENURE), constituting 30%, and pure water (50%).

The cost of fertilizer production in the processing of manure is about EUR 18-23 per tonne [Smit 2022]. RENURE can be used as a substitute for synthetic mineral fertilizers and sold for around 80% of the value of synthetic nitrogen fertilizer (EUR 1.0-1.5 per kg N)[4].

[4] The price of mineral fertilizer (e.g. calcium ammonium nitrate – CAN) was approx. EUR 85 per 100 kg [Smit 2022].

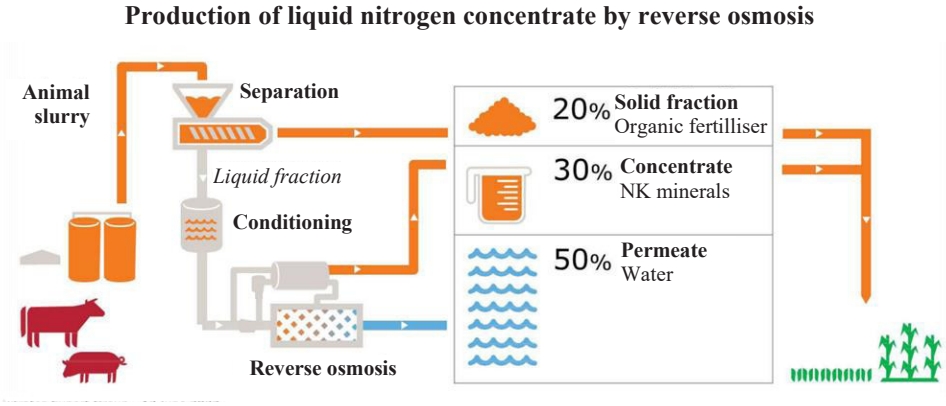

Figure 7. Production of liquid nitrogen concentrate by reverse osmosis
Source: [Smit 2022]

Farmers producing these fertilizers do not bear the cost of exporting livestock manure from their farm, which currently amounts to EUR 15-20 per tonne, depending on the region and season. The potential for the use of RENURE in this country is large. As reported by H.J. Smit [2022], agriculture used 200 million kg of synthetic nitrogen fertilizers. The volume of exported manure expressed in nitrogen increased to almost 60 million kg N in 2020 (Figure 8).

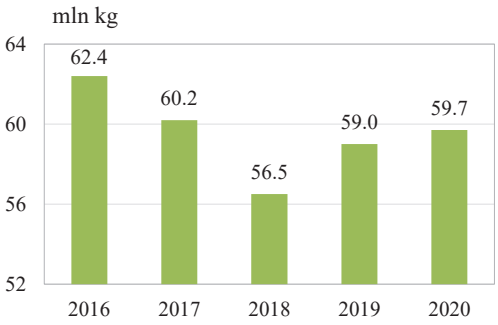

Figure 8. Total nitrogen export in the Netherlands in 2016-2020
Source: [Smit 2022]

Assuming a transport distance of up to 25 km from the RENURE production site, the production-related emissions are estimated to be 0.54-1.3 kg CO_2 equivalent per kg N, which is lower than the assumed value for mineral fertilizers. Based on these assumptions, a lower negative impact of the production of RENURE fertilizers on the climate can be expected. On the other hand, assuming the option of long-distance transport (approx. 150 km), which is likely in the case of RENURE, these emissions will increase significantly. In this scenario, the impact of transport becomes more pronounced and exceeds the impact of fertilizer production, or even exceeds the emission of mineral fertilizers several times [Huygens et al. 2020].

Table 1. Key parameters for production, cost and exports of RENURE in the Netherlands

Production	400 thousand tonnes = 2,5 mln kg N
Amount of nitrogen in 1 m^3 of finished product	6-8 kg
Number of manure processing companies	approx. 160
Production costs in three fractions	18-23 EUR/tonne
Export costs	15-20 EUR/tonne
Approximate price of RENURE	80% mineral fertilizer values (80% × 85 EUR/100 kg)
Export	60 mln kg N

Source: own elaboration based on [Huygens et al. 2022, Smit 2022]

RENURE – FOR FURTHER DISCUSSION

According to the assumptions of the European Commission, the use of a RENURE product must not cause additional adverse effects on the natural environment and risks to human health compared to the current regulatory framework. The literature analysis and information collected from the Nitrates Expert Group indicated the need to investigate the impact of a possible implementation of RENURE on the following issues: gaseous emissions from RENURE when they are applied to soil, soil fertility change, spread of pathogens and zoonoses, spread of contaminants including veterinary medicines, phosphorus management and climate change impacts resulting from RENURE production [Huygens et al. 2020]. Analyses to date have identified potential risks. In particular, the storage and use of RENURE may be susceptible to ammonia losses and consequent air pollution and odour nuisance due to physical parameters. It is assumed that local adverse effects can be minimised by the quality requirements for the composition of RENURE, the processing requirements laid down in Regulations (EC) No 1069/2009 and (EU) No 142/2011, on livestock by-products and future the EU initiatives to eliminate the risks associated with veterinary residues upstream in the supply chain. RENURE parameters will enforce higher standards of storage and use practices.

The EC Joint Research Centre (JRC EC) has assessed the impact of RENURE on the environment and human health and proposed criteria for it, provided that its possible wider implementation does not affect the total amount of manure produced in the EU, the conversion population and the stocking density of livestock.

Together with other the EU legislation and policies, including the Water Framework Directive 2000/60/EC and the Common Agricultural Policy (CAP), the Nitrates Directive is now one of the pieces of the EU legislation that controls the environmental impact of the livestock sector by reducing the amount of livestock manure applied to agricultural

land. Taking this into account, the transformation of manure into RENURE can be an effective management method to protect waters from nitrate pollution from agricultural production and to provide appropriate agronomic benefits. Therefore, at the current stage of agricultural development in Poland, but also in other the EU countries, it is important to minimize the loss of components in natural fertilizers through practices, such as:

– maximum limitation of losses of ammoniacal nitrogen due to evaporation;
– dilution of slurry (which can reduce ammonia losses by 44 to 90%);
– spreading slurry at the end of winter and during the growing season on permanent grassland;
– spreading slurry directly before sowing;
– instant mixing of manure with soil – the greatest nitrogen losses occur within a few hours after spreading manure on the surface of the field;
– proper storage of manure – with improper storage, losses of nitrogen and organic matter can reach up to 60% [MODR 2015].

SUMMARY

The production of natural fertilizers is associated with their proper management. The way of managing manure depends on the production potential of a given country and trade opportunities. Due to the significant impact of natural fertilization on the state of the environment and climate, the form of natural fertilizers and the way they are handled are particularly important.

Agriculture in the EU is highly diversified in many respects. The case of the Netherlands, which has implemented the pilot program for the production of RENURE fertilizers, results from the specificity of their agriculture – a small area of the country, a very large population and a stocking density of livestock. These are the features of agriculture that definitely distinguish the Netherlands from other the EU countries. The problem is also illustrated by the high surplus of the nitrogen balance.

The amount of manure produced – which is significant in the case of the Netherlands – is a challenge in terms of their proper storage, application and transport. The essence of RENURE was to find a way to effectively manage natural fertilizers, both in terms of environment and climate, as well as production and economy. In the case of the Netherlands, it seems reasonable to look for new technological solutions enabling the processing of natural fertilizers. A Dutch pilot study indicated that, according to a set of criteria, certain manure-derived products can be safely used as a replacement for chemically produced nitrogen fertilizers, without increasing the risk of nitrate leaching. RENURE fertilizer production means farmers could apply more nitrogen from processed manure and potentially reduce the amount of mineral fertilizer that is currently applied to farmland.

This is in line with the objectives of the Circular Economy Action Plan and provides an opportunity to promote recycled nutrients that can replace nutrients from primary raw materials, such as synthetically produced fertilizers.

In addition to the positive test results in the indicated ranges, there are many reservations concerning, for example, the amount of CO_2 emissions resulting from the transport of the RENURE product. An important issue is also the proper storage and application of this fertilizer. Due to the high concentration of nitrogen, storage standards and high precision of application – management of this fertilizer – it is indispensable to protect the natural environment and climate. It should be stressed that the application of best agricultural practices requires access to information, as well as universal education, both on the importance of the new fertilizing product and how to handle it. In addition to the prerequisites for further research on RENURE, the challenges of its further dissemination among farmers and processors are also an important issue.

The case of the Netherlands does not mean that the proposed solutions should be implemented uncritically in other countries. Countries that face similar agricultural challenges as the Netherlands can seek similar solutions. In the case of Poland, which differs significantly in terms of agricultural potential, organization and natural management conditions, the economic and environmental viability of the introduction of RENURE may be called into question, taking into account the entire agricultural sector.

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RENURE – PRZETWORZONE NAWOZY NATURALNE. WYBRANE KWESTIE ŚRODOWISKOWE I PRODUKCYJNO-EKONOMICZNE

Słowa kluczowe: RENURE, nawozy naturalne, Europejski Zielony Ład, zrównoważony rozwój rolnictwa, Niderlandy

ABSTRAKT. Celem artykułu jest przybliżenie istoty nawozów naturalnych w formie RENURE, biorąc pod uwagę kwestie środowiskowe i produkcyjno-ekonomiczne. Od kilkudziesięciu lat realizowane są programy i strategie na rzecz zrównoważonego rozwoju, które mają zasięg międzynarodowy. Potrzebę realizacji różnych celów w prowadzonej działalności gospodarczej podkreśla także strategia Europejskiego Zielonego Ładu, wprowadzona pod koniec 2019 roku. Ważnym jego elementem jest poprawne gospodarowanie nawozami naturalnymi, zarówno ze względów środowiskowych, jak i produkcyjno-ekonomicznych. Przedstawiono przypadek Niderlandów, w którym wprowadzono pilotażowe badania nad przetworzeniem nawozów naturalnych w postać RENURE. W badaniu wykorzystano źródła literatury oraz wybrane, najnowsze statystyki pochodzące z zasobów Eurostat (2019, 2020). Zobrazowano rolnictwo w krajach Unii Europejskiej w kontekście produkcji i możliwości wykorzystani nawozów naturalnych. Analiza danych statystycznych wskazała, że rolnictwo w UE jest silnie zróżnicowane pod względem gospodarki nawozami naturalnymi. Przypadek Niderlandów, które wdrożyły pilotaż RENURE wynika ze specyfiki ich rolnictwa – małej powierzchni kraju, bardzo wysokiego pogłowia i wysokiej obsady zwierząt. Kraje, które zmagają się z podobnymi wyzwaniami w rolnictwie jak Niderlandy, powinny poszukiwać zbliżonych rozwiązań. W przypadku Polski, która znacząco różni się pod względem organizacji rolnictwa i jego przyrodniczych warunków gospodarowania, zasadność ekonomiczna, jak i środowiskowa wprowadzenia RENURE nie znajduje uzasadnienia w skali całego sektora.

AUTHORS

WIOLETTA WRZASZCZ, PHD
ORCID: 0000-0003-2485-3713
Institute of Agricultural Economics and Food Economy
– National Research Institute, Poland
e-mail: wrzaszcz@ierigz.waw.pl

JOLANTA SOBIERAJEWSKA, MSC
ORCID: 0000-0002-5161-696X
Institute of Agricultural Economics and Food Economy
– National Research Institute, Poland
e-mail: sobierajewska@ierigz.waw.pl

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